RESEARCH HIGHLIGHT
Basic Energy Sciences Program
Geosciences Subprogram

Title: Continuum and Particle Level Modeling of Concentrated Suspension Flows

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Objectives: The purpose of this program is to combine experiments, computations, and theory to make fundamental advances in our ability to predict transport phenomena in concentrated, multiphase, disperse systems, particularly when flowing through geologic media.

Results: Experiments have been performed to characterize shear-induced particle migration in suspensions, including the influence of particle size, surface roughness, and volume fraction. An existing continuum diffusive-flux model [Phillips et al., "A constitutive equation for concentrated suspensions that accounts for shear-induced particle migration," *Phys. Fluids A* **4**, 30-40 (1992)] is evaluated in terms of the experimental data.

The first objective of this work was to examine possible effects of surface roughness on the rate of particle demixing in a wide-gap Couette apparatus. No discernible differences occurred between the demixing rates of suspensions containing rough particles and those containing smooth particles.

The second objective was to determine a scaling factor from the rate of demixing of suspended particles with respect to the particle radius. Using the new experimental results, a revised estimate of the scaling factor is estimated to be 2.9. This scaling factor applies to flows with a gap to particle diameter ratio of about 10.

The third objective was to study different forms of the coefficients K_c and K_m, which act as tuning parameters for the phenomenological diffusive-flux model for shear-induced migration. Previous use of this model has been based upon a constant coefficient ratio for K_c / K_m. Optimization of this ratio based on an experimental error measure indicates that K_c / K_m is best modeled as a monotonically increasing function of the local particle concentration.

Significance: In an overall sense, the phenomenological model produces good correlation with experimentally determined concentration profiles in the gap region removed from the walls. The model remains an effective tool for prediction of concentration profiles brought about by shear-induced migration of suspended particles. The improved model now can be used for a wide range of overall volume fractions of particles. Furthermore, suspensions found in geoscience applications are rarely smooth perfect spheres. From these data, one can reasonably conjecture that particle roughness plays at most a minor role in the rate of demixing. The experiments are relevant to flows in which the particles are relatively large compared to the characteristic gap between bounding walls, as would often occur in porous geologic media. However, experiments similar to these reported here, but for larger gap to particle diameter ratios, are needed for applications where the particles are small compared to the characteristic flow dimensions.

Publication:
N. Tetlow, A. L. Graham, M. S. Ingber, S. R. Subia, L. A. Mondy, and S. A. Altobelli, "Particle migration in a Couette apparatus: Experiment and modeling," *J. Rheol*. **42**, 307-327 (1998).